

# Máquina de Turing Universal

Estas notas sobre MTuring Universal no pretenden ser unos apuntes sobre este tema, sino tan solo unas notas que faciliten la comprensión de esta materia a través de la explicación del profesor. Permiten atender a la explicación sin tener que tomar apuntes simultáneamente.

Se componen de:

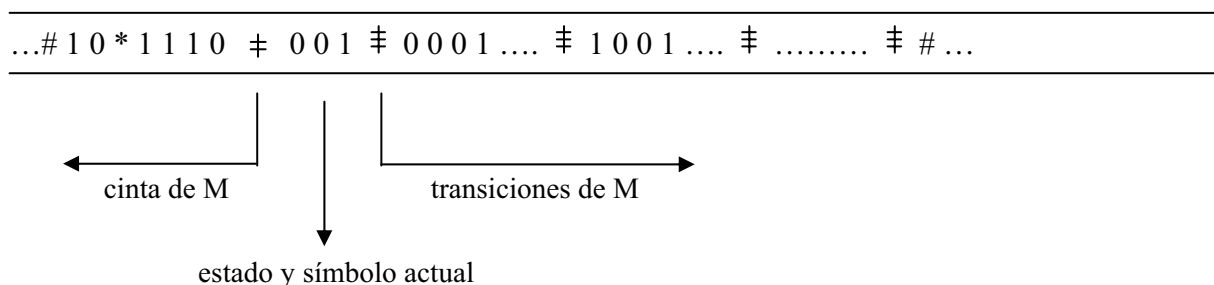
- 1) Una muy ligera explicación de como funciona la MTU que se explica en clase; pag 1.
- 2) La función de transición de esa MTU, en forma de tabla y como diagrama de transición; pags 2 a 5.
- 3) y un ejemplo de cómo funciona esa versión de la MTU simulando una MT concreta; pags 6 a 10.

## Cinta de la Máquina de Turing Universal

Sea M la máquina de Turing que se está simulando. En la cinta de la máquina de Turing Universal (MTU) y en cada instante de la simulación se refleja la siguiente información:

- función de transición de la máquina M que se está simulando.
- cinta de la máquina M
- estado y posición de la cabeza de lectura-escritura de M.

Todo ello se codifica con 0,s y 1,s. Y se coloca en determinadas zonas de la MT Universal separados por los símbolos  $\#$  y  $\$$



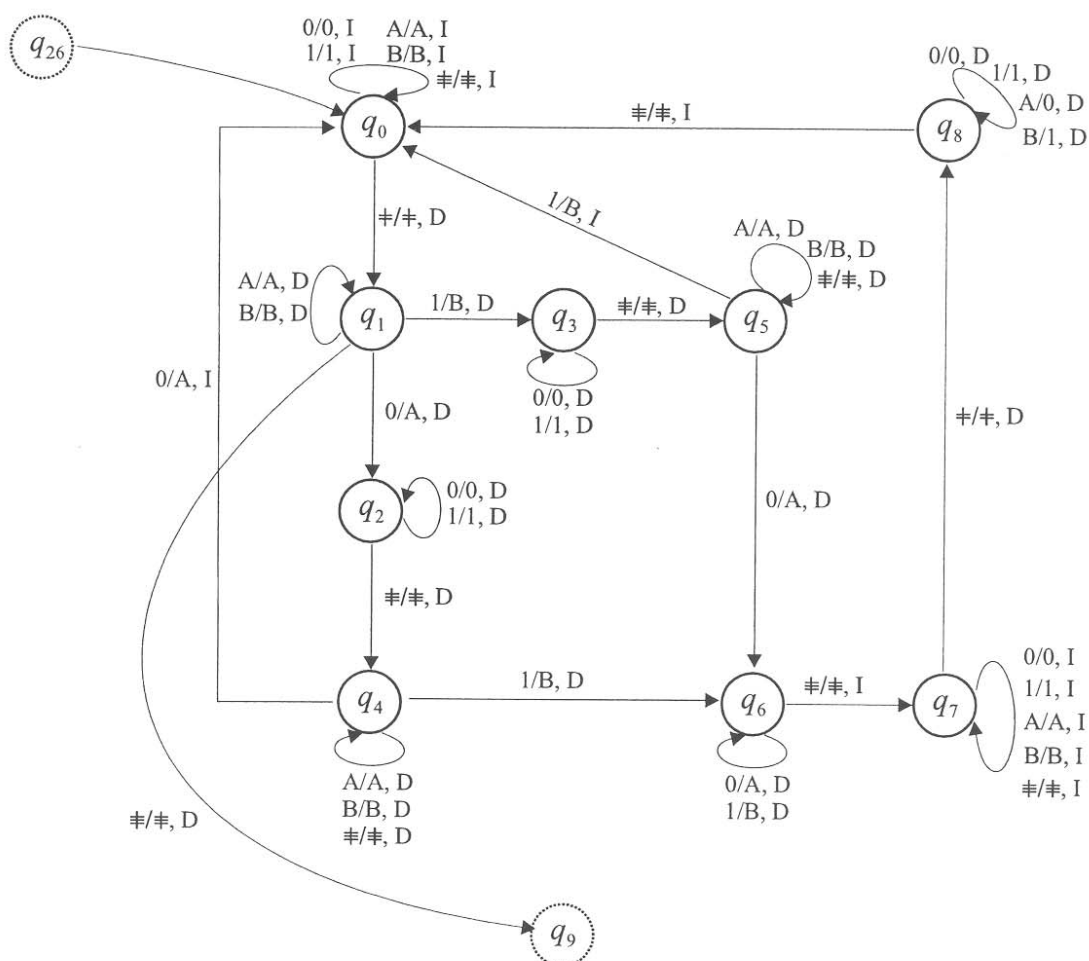


Figura 1: Módulo localizador de la MTU. Estados: del  $q_0$  al  $q_8$ .

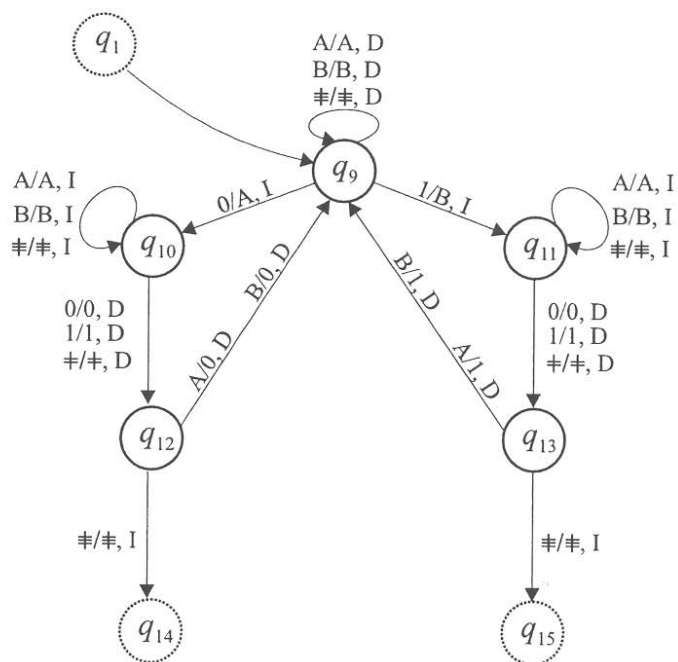
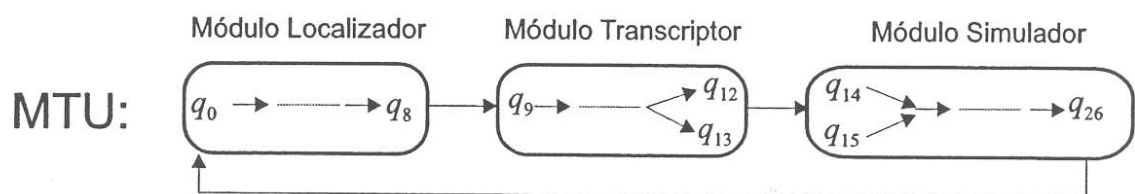
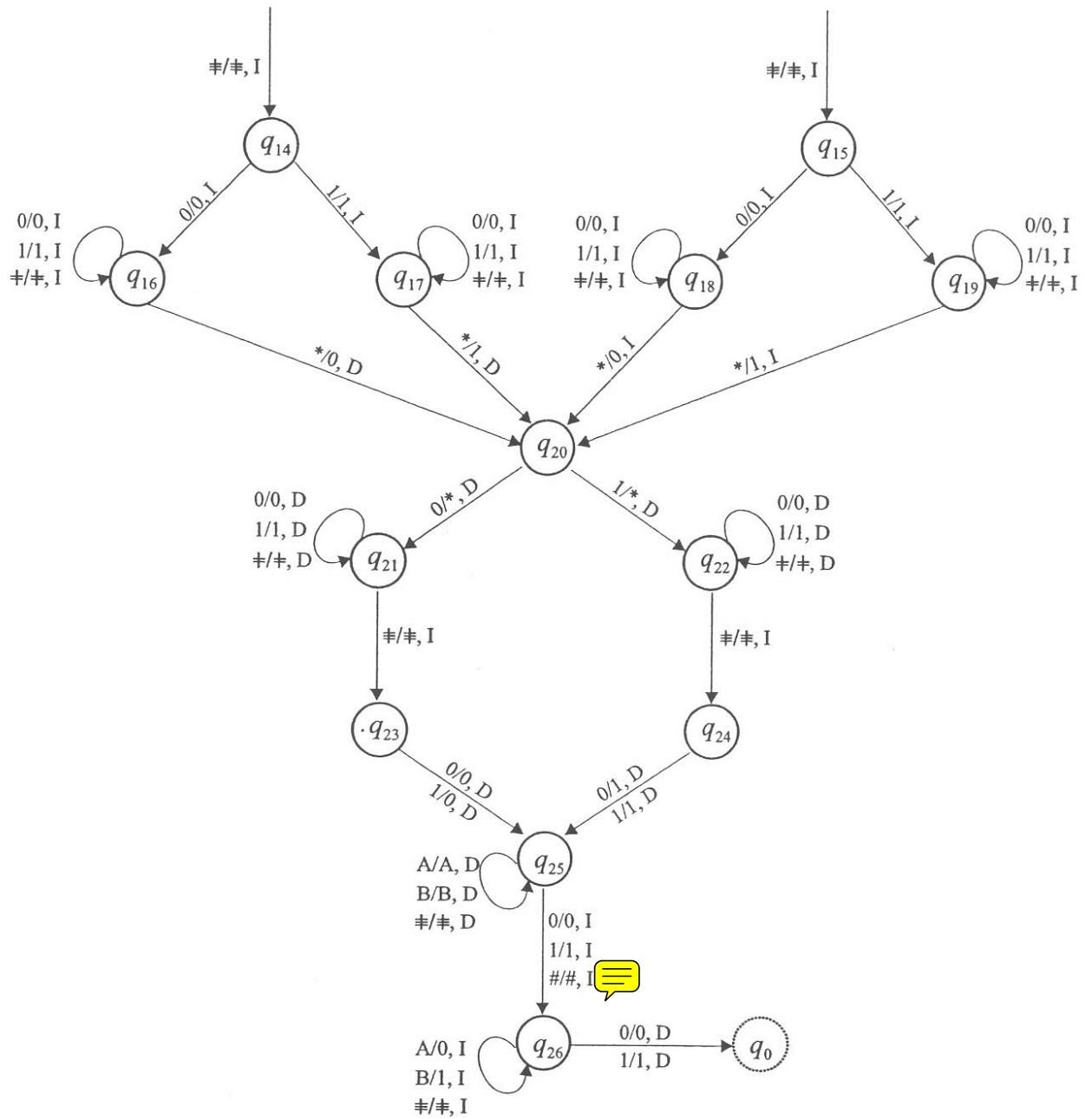


Figura 2: Módulo transcriptor de la MTU. Estados: del  $q_9$  al  $q_{12}$  o  $q_{13}$ .



## Ejemplo del funcionamiento de la MTU

Las páginas siguientes muestran detalladamente el comienzo de la ejecución de la computación que realiza la MTU cuando simula la máquina M que suma dos números unarios

- cuya función de transición viene dada por la siguiente tabla

|                | 1                  | #                  |
|----------------|--------------------|--------------------|
| q <sub>0</sub> | q <sub>0</sub> 1 D | q <sub>1</sub> 1 D |
| q <sub>1</sub> | q <sub>1</sub> 1 D | q <sub>2</sub> # I |
| q <sub>2</sub> | q <sub>2</sub> # D | —                  |

- y cuando la configuración inicial (estado inicial, cinta inicial y posición de la cabeza de lectura escritura) es la siguiente:

q<sub>0</sub> 1 1 # 1 1 1

Nota importante: imprime las siguientes páginas a una sola cara y colócalas de la siguiente manera:

|        |       |
|--------|-------|
| pag 7  | pag 8 |
| pag 9  |       |
| pag 10 |       |

|    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9              | 10             | 11             | 12             | 13             | 14              | 15              | 16              | 17             | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|----|---|---|---|---|---|---|---|---|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|----------------|----|----|----|----|----|----|----|----|
| 1  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | 0              | 0              | 1              | q <sub>0</sub> | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  | 0  | 0  | 0  |
| 2  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | 0              | 0              | q <sub>0</sub> | 1              | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  | 0  | 0  | 0  |
| 3  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | 0              | q <sub>0</sub> | 0              | 1              | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 4  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>0</sub> | 0              | 0              | 1              | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 5  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | q <sub>0</sub> | *              | 0              | 0              | 1              | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 6  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>1</sub> | 0              | 0              | 1              | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 7  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | q <sub>2</sub> | 0              | 1              | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 8  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | 0              | q <sub>2</sub> | 1              | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 9  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | 0              | 1              | q <sub>2</sub> | *               | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 10 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | 0              | 1              | *              | q <sub>4</sub>  | 0               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 11 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | 0              | 1              | q <sub>0</sub> | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 12 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | 0              | q <sub>0</sub> | 1              | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 13 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | q <sub>0</sub> | 0              | 1              | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 14 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>0</sub> | A              | 0              | 1              | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 15 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | q <sub>0</sub> | *              | A              | 0              | 1              | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 16 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>1</sub> | A              | 0              | 1              | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 17 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | q <sub>1</sub> | 0              | 1              | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 18 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | q <sub>2</sub> | 1              | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 19 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | 1              | q <sub>2</sub> | *               | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 20 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | 1              | *              | q <sub>4</sub>  | A               | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 21 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | 1              | *              | A               | q <sub>4</sub>  | 0               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 22 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | 1              | *              | q <sub>0</sub>  | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 23 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | 1              | q <sub>0</sub> | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 24 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | q <sub>0</sub> | 1              | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 25 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | q <sub>0</sub> | A              | 1              | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 26 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>0</sub> | A              | A              | 1              | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 27 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | q <sub>0</sub> | *              | A              | A              | 1              | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 28 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>1</sub> | A              | A              | 1              | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 29 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | q <sub>1</sub> | A              | 1              | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 30 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | q <sub>1</sub> | 1              | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 31 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | q <sub>3</sub> | *               | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 32 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | q <sub>5</sub>  | A               | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 33 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | q <sub>5</sub>  | A               | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 34 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | A               | q <sub>5</sub>  | 1              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 35 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | q <sub>0</sub>  | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 36 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | q <sub>0</sub>  | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 37 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | q <sub>0</sub> | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 38 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | q <sub>0</sub> | B              | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 39 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | q <sub>0</sub> | A              | B              | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 40 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>0</sub> | A              | A              | B              | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 41 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | q <sub>0</sub> | *              | A              | A              | B              | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 42 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | q <sub>1</sub> | A              | A              | B              | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 43 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | q <sub>1</sub> | A              | B              | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 44 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | q <sub>1</sub> | B              | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 45 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | q <sub>1</sub> | *               | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 46 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | q <sub>9</sub>  | A               | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 47 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | q <sub>9</sub>  | A               | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 48 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | A               | q <sub>9</sub>  | B              | 0  | 0  | 1  | 0  | *  |    |    |    |
| 49 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | A               | B               | q <sub>9</sub> | 0  | 0  | 1  | 0  | *  |    |    |    |
| 50 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | A               | q <sub>10</sub> | B              | A  | 0  | 1  | 0  | *  |    |    |    |
| 51 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | A               | q <sub>10</sub> | A               | B              | A  | 0  | 1  | 0  | *  |    |    |    |
| 52 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *              | A              | A              | B              | *              | q <sub>10</sub> | A               | A               | B              | A  | 0  | 1  | 0  | *  | 0  | 0  | 0  |

26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54

0 1 1 0 \* 0 1 1 0 1 1 0 \* 0 1 0 1 0 0 1 \* 1 0 1 1 0 0 0 \*

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|     | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9               | 10              | 11              | 12              | 13              | 14              | 15              | 16              | 17              | 18              | 19              | 20             | 21 | 22 | 23 | 24 | 25 |
|-----|---|---|---|---|---|---|---|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|----|----|----|----|----|
| 52  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | A               | A               | B               | *               | q <sub>10</sub> | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 53  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | A               | A               | B               | q <sub>10</sub> | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 54  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | A               | A               | q <sub>10</sub> | B               | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 55  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | A               | q <sub>10</sub> | A               | B               | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 56  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | q <sub>10</sub> | A               | A               | B               | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 57  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | q <sub>10</sub> | *               | A               | A               | B               | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 58  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | q <sub>12</sub> | A               | A               | B               | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 59  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | q <sub>9</sub>  | A               | B               | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 60  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | q <sub>9</sub>  | B               | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 61  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | q <sub>9</sub>  | *               | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 62  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | q <sub>9</sub>  | A               | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 63  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | A               | q <sub>9</sub>  | A               | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 64  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | A               | A               | q <sub>9</sub>  | B               | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 65  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | A               | A               | B               | q <sub>9</sub>  | A               | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 66  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | A               | A               | B               | A               | q <sub>9</sub>  | 0               | 1              | 0  | *  | 0  | 0  | 0  |
| 67  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | A               | A               | B               | q <sub>10</sub> | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 68  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | A               | A               | q <sub>10</sub> | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 69  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | A               | q <sub>10</sub> | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 70  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | *               | q <sub>10</sub> | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 71  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | B               | q <sub>10</sub> | *               | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 72  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | A               | q <sub>10</sub> | B               | *               | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 73  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | q <sub>10</sub> | A               | B               | *               | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 74  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | q <sub>10</sub> | 0               | A               | B               | *               | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 75  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | q <sub>12</sub> | A               | B               | *               | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 76  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | q <sub>9</sub>  | B               | *               | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 77  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | q <sub>9</sub>  | *               | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 78  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | q <sub>9</sub>  | A               | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 79  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | q <sub>9</sub>  | A               | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 80  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | A               | q <sub>9</sub>  | B               | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 81  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | A               | B               | q <sub>9</sub>  | A               | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 82  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | A               | B               | A               | q <sub>9</sub>  | A               | 1              | 0  | *  | 0  | 0  | 0  |
| 83  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | A               | B               | A               | A               | q <sub>9</sub>  | 1              | 0  | *  | 0  | 0  | 0  |
| 84  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | A               | B               | A               | q <sub>11</sub> | A               | B              | 0  | *  | 0  | 0  | 0  |
| 85  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | A               | B               | q <sub>11</sub> | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 86  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | A               | q <sub>11</sub> | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 87  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | A               | q <sub>11</sub> | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 88  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | *               | q <sub>11</sub> | A               | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 89  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | B               | q <sub>11</sub> | *               | A               | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 90  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | q <sub>11</sub> | B               | *               | A               | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 91  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | q <sub>11</sub> | 0               | B               | *               | A               | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 92  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | q <sub>13</sub> | B               | *               | A               | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 93  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | q <sub>9</sub>  | *               | A               | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 94  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | q <sub>9</sub>  | A               | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 95  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | q <sub>9</sub>  | A               | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 96  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | q <sub>9</sub>  | B               | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 97  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | B               | q <sub>9</sub>  | A               | A               | B              | 0  | *  | 0  | 0  | 0  |
| 98  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | q <sub>9</sub>  | A               | B              | 0  | *  | 0  | 0  | 0  |
| 99  | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | q <sub>9</sub>  | B              | 0  | *  | 0  | 0  | 0  |
| 100 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | q <sub>9</sub> | 0  | *  | 0  | 0  | 0  |
| 101 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | q <sub>10</sub> | B              | A  | *  | 0  | 0  | 0  |
| 102 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | q <sub>10</sub> | A               | B              | A  | *  | 0  | 0  | 0  |
| 103 | # | * | 1 | 0 | 1 | 1 | 1 | 0 | *               | 0               | 0               | 1               | *               | A               | A               | B               | q <sub>10</sub> | A               | A               | B              | A  | *  | 0  | 0  | 0  |

|     | 1 | 2               | 3               | 4               | 5               | 6               | 7               | 8               | 9               | 10              | 11              | 12              | 13              | 14              | 15              | 16              | 17              | 18              | 19              | 20              | 21              | 22              | 23 | 24 | 25 |
|-----|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----|----|----|
| 103 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | q <sub>10</sub> | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 104 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | q <sub>10</sub> | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 105 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | q <sub>10</sub> | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 106 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | q <sub>10</sub> | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 107 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | q <sub>10</sub> | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 108 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | q <sub>10</sub> | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 109 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | q <sub>12</sub> | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 110 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | q <sub>14</sub> | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 111 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | q <sub>17</sub> | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 112 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | q <sub>17</sub> | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 113 | # | *               | 1               | 0               | 1               | 1               | 1               | 0               | q <sub>17</sub> | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 114 | # | *               | 1               | 0               | 1               | 1               | 1               | q <sub>17</sub> | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 115 | # | *               | 1               | 0               | 1               | 1               | q <sub>17</sub> | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 116 | # | *               | 1               | 0               | 1               | q <sub>17</sub> | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 117 | # | *               | 1               | 0               | q <sub>17</sub> | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 118 | # | *               | 1               | q <sub>17</sub> | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 119 | # | *               | q <sub>17</sub> | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 120 | # | q <sub>17</sub> | *               | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 121 | # | 1               | q <sub>20</sub> | 1               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 122 | # | 1               | *               | q <sub>22</sub> | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 123 | # | 1               | *               | 0               | q <sub>22</sub> | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 124 | # | 1               | *               | 0               | 1               | q <sub>22</sub> | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 125 | # | 1               | *               | 0               | 1               | 1               | q <sub>22</sub> | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 126 | # | 1               | *               | 0               | 1               | 1               | 1               | q <sub>22</sub> | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 127 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | q <sub>22</sub> | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 128 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | q <sub>22</sub> | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 129 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | q <sub>22</sub> | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 130 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | q <sub>22</sub> | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 131 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | q <sub>22</sub> | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 132 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | q <sub>24</sub> | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 133 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | q <sub>25</sub> | *               | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 134 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | q <sub>25</sub> | A               | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 135 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | q <sub>25</sub> | A               | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 136 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | q <sub>25</sub> | B               | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 137 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | q <sub>25</sub> | A               | A               | B               | A               | *               | 0  | 0  | 0  |
| 138 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | q <sub>25</sub> | A               | B               | A               | *               | 0  | 0  | 0  |
| 139 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | q <sub>25</sub> | B               | A               | *               | 0  | 0  | 0  |
| 140 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | q <sub>25</sub> | A               | *               | 0  | 0  | 0  |
| 141 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | q <sub>25</sub> | *               | 0  | 0  | 0  |
| 142 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | *               | q <sub>25</sub> | 0  | 0  | 0  |
| 143 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | A               | q <sub>26</sub> | *               | 0  | 0  | 0  |
| 144 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | B               | q <sub>26</sub> | A               | *               | 0  | 0  | 0  |
| 145 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | A               | q <sub>26</sub> | B               | 0               | *               | 0  | 0  | 0  |
| 146 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | A               | q <sub>26</sub> | A               | 1               | 0               | *               | 0  | 0  | 0  |
| 147 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | B               | q <sub>26</sub> | A               | 0               | 1               | 0               | *               | 0  | 0  | 0  |
| 148 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | A               | q <sub>26</sub> | B               | 0               | 0               | 1               | 0               | *               | 0  | 0  | 0  |
| 149 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | A               | q <sub>26</sub> | A               | 1               | 0               | 0               | 1               | 0               | *               | 0  | 0  | 0  |
| 150 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | *               | q <sub>26</sub> | A               | 0               | 1               | 0               | 0               | 1               | 0               | *               | 0  | 0  | 0  |
| 151 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | q <sub>26</sub> | *               | 0               | 0               | 1               | 0               | 0               | 1               | 0               | *               | 0  | 0  | 0  |
| 152 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | q <sub>26</sub> | 1               | *               | 0               | 0               | 1               | 0               | 0               | 1               | 0               | *               | 0  | 0  | 0  |
| 153 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | 1               | q <sub>0</sub>  | *               | 0               | 0               | 1               | 0               | 0               | 1               | 0               | *               | 0  | 0  | 0  |
| 154 | # | 1               | *               | 0               | 1               | 1               | 1               | 0               | *               | 0               | 0               | q <sub>0</sub>  | 1               | *               | 0               | 0               | 1               | 0               | 0               | 1               | 0               | *               | 0  | 0  | 0  |